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ROYAL

# Geological Society of Cornwall.

TWENTY-EIGHTH

# ANNUAL REPORT

## OF THE COUNCIL,

WITH

## THE PRESIDENT'S ADDRESS,

AND

## *PAPERS AND NOTICES*

READ TO THE SOCIETY.

PENZANCE:
PRINTED BY R. D. RODDA, BOOKSELLER AND STATIONER.

1841.

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# ROYAL GEOLOGICAL SOCIETY OF CORNWALL.

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# PRESIDENT'S ADDRESS.

However interesting may be the retrospect which shows the advance of geological science in this county, there are other recollections which we are also bound to entertain, more melancholy in their impression, but, at the same time, involving a sacred duty which we owe to those whose course is finished, but who in their lifetime were benefactors to this society in particular. Amongst those most prominent stands the name of Sir Humphrey Davy. It is true that his loss is not of recent occurrence; but as the subject of his career has been lately taken up anew, and it is in comtemplation to erect a monument to his fame, which shall speak to the eye as the records of science speak to the understanding, I have thought it right to explain to you, and through you to the Cornish public, the steps which have been taken to do honour to the memory of a man who has done so much honour to his own native county. During the sitting of the British Association at Plymouth, a few gentlemen met together to consult on the means by which this object might be accomplished. It was thought desirable that the movement should commence in that assembly of men of science brought from all parts of the empire; thus to give the undertaking a general rather than a local aspect, and to show that his character, as it belonged to the country at large, so it was acknowledged and received as a benefit to the whole community. In that early stage, no more could be done than to take down the names of such as were willing to lend their aid, and to appoint two honorary secretaries, whose duty it would be to make known the object in view, to collect subscriptions, and, at a proper time, to convene an assembly of those interested, to whom they might make a report of their progress. It is intended that this meeting should take place in the course of the ensuing spring, and in London. The secretaries appointed were Mr. Hoblyn and Mr. Winsor. From the latter I have received two letters, in

one of which he tells me that they are about to circulate lithographed notices of what passed at Plymouth, together with the names of the subscribers then and subsequently obtained. But the undertaking has not yet met with the full amount of support which was anticipated, principally, Mr. Winsor says, on account of an objection to the erection of the monument in Cornwall, where so few, except residents, will have an opportunity of seeing it. Under these circumstances, it appears probable that the undertaking will drop, unless taken up warmly by this county and neighbourhood. If we can show that we are willing to make an effort on our part, perhaps auxiliary contributions may be drawn from a distance; but it appears from the tone of Mr. Winsor's letters, and the discouragement which he has felt, that the public are not inclined to look with favour on the project as it is now offered to them. I would therefore venture to recommend, either that a subscription list be immediately opened amongst ourselves, or that some other means be taken, by the appointment of a committee or otherwise, to ascertain the willingness of the county to lay the foundation of a subscription, to which others at a distance may be then very properly asked to contribute.

Since our last meeting, the science and literature of the county generally, and the geological society in particular, have met with a severe loss by the death of one of its earliest members and most copious contributors, Mr. Hawkins, of Trewithen, and Bignor Park. From the first commencement of the society, his papers have formed a valuable part of our transactions; and I have reason to believe that his contributions would have continued to be as frequent as heretofore, had the publication of our volumes been more regular, and kept pace with the rapid progress of a science which from year to year has advanced, and is advancing through spaces before untrodden, and amongst prospects perpetually enlarging. Mr. Hawkins's papers in our transactions are nineteen in number, and they display in strong colours the varied stores of his mind, derived from the lights of history and science, and from a close attention to the practical and economical bearing of geology on the great interests of his native county. Mr. Hawkins's fame as a scientific man would have stood even higher than it does, had his innate modesty allowed him to publish to the world his facts

and views at the periods when he discovered or formed them; but, by reason of the delay thus occasioned, many things were subsequently brought forward by others, of which the credit really belonged to him. The objection which he and some others have felt to the tardy publication of our transactions, has led the council to recommend to the society the adoption of a plan somewhat differing from that hitherto pursued, whereby to secure the prompt distribution of any valuable matter which may from time to time be brought before us. The society has likewise to lament the death of Mr. H. P. Tremenheere, who, although not a scientific man, has from the beginning supported the society, and felt a strong interest in its success. To Mr. Benjamin Sampson, whose demise also occurred during the past year, we owe the first document (a plan and section of a mine), which was sent to the society after its establishment.

The plan to which I have alluded is as follows: Instead of reserving all the communications until they would fill a volume of respectable size, as has been hitherto done, it is proposed that in future our publications should be in yearly parts or *fasciculi*, to be delivered shortly after the annual meetings, and to contain the actual record of the events and transactions of the year then closed. These may be bound when convenient, and still be made uniform with the valuable publications which have already issued from the society. It may (and probably would) become necessary to publish occasionally a supplemental and entire volume whenever we become possessed of a complete treatise, such as that of Dr. Boase, and the report of Mr. Henwood, which is now in course of printing; but highly important as such treatises are, it may be inconvenient to delay the communication of other interesting matter on their account only, and thus leave the county to suppose that the Geological Society is inactive.

The Council have imagined that as the science of geology tends to pour its streams over the being and happiness of that important class, the practical miners of the county, so they might hope to draw from that class treasures of practical observation, to be ripened in their hands into science. With this view they have accepted the offer which I have made of a premium of £5, to be distributed

in small sums to working miners, who shall report to the society any unusual occurrences which have come practically under their observation. The object of this premium is to place the actual miner in immediate relation with the society, to give him an interest in its proceedings, and to awaken in his mind an attention to those anomalies which frequently present themselves in his pursuit, the scientific value of which may be by no means heeded or understood by him. To him they may be only strange appearances, or at best, objects of admiration and curiosity; but there may still be truths of great importance concealed under such apparent departures from the ordinary course of nature—truths which may have a direct tendency to flow back on the miner himself through the channels of science. The value of such knowledge is not for us alone. The constant supply of facts, if we should thus succeed in obtaining it, drawn from sources almost exclusively in possession of this county, and brought to light by this society, will bring us into closer connection with the Geological Society of London, and with other societies, of which the promotion of geological science is one of the principal objects, and turn their attention with greatly increased interest to our proceedings and publications. It will, of course, be left to the Council to determine the form in which the premium which I have offered shall be rendered available for its objects; but it has occurred to me to suggest that the present meeting should appoint two or three gentlemen as a committee of award, and that to them should be sent any communications having a claim to the premium. I think they might refer each notice separately to some one member of the society at large, who might not only give his opinion of the value of the fact reported, but make such remarks on it as may occur to himself. Thus a constantly increasing current may be set in motion, bearing with it all the freshness of discovery, combined with the matured science of some of our more instructed members. If this plan should succeed, as I hope it will ultimately succeed, the premium which I have offered will be soon exhausted; and it is for the society to determine whether they will place at the disposal of the Council a small sum, to be applied, if necessary, in supplying any deficiency which may occur.

The necessity of providing space to receive our constantly increasing collections again painfully presses on us; and is rendered more urgent by the prospect of a large addition to our museum from the Cornish organic fossils, which are now found to be abundant. Till lately the existence of such fossils was either absolutely denied, or very sparingly admitted; and we were supposed to be almost entirely without that key to the knowledge of our strata. Borlase describes none which may not be considered either as accidental forms of mundic, or recent concretions on the shores of our harbours, containing the exuviæ of none but existing species of shell fish. The mode in which he accounts for the absence of organic remains in Cornwall is characteristic of the state of knowledge in his time, and so far historically interesting. He seems to have entertained an idea that no fossiliferous beds could possibly have existed previous to the Noahchian deluge; and that it is because the waters of that deluge happened to contain in some other places more of what he calls the "suspended spar" in which these fossils were to be imbedded; petrifactions found elsewhere are wanting here. Geology has made rapid strides since his day; but it would be unjust to Borlase not to admit that his sober views, on many points, place him at least as much in advance of those who preceded him by about an equal interval to that by which he has preceded us, as he has been left behind by his successors. Thus we find, that about eighty years prior to Borlase, Sir John Pettus, in his Fodinæ Regales, reasoned in the following terms on the cause of the inequalities of the earth's surface: "When God breathed upon the waters, it was a petrifying breath, and such waters as were quiet became plains, the boisterous waters becoming hills according to the proportion of the billows." But to return to the matter of Cornish fossils. I cannot find, in the four volumes of our transactions already published, any paper on the subject; nor, with the exception of a note quite at the end of Dr. Boase's treatise (in which he retracts his denial of the existence of fossil remains in Cornwall, with respect to one locality only, Tintagel), is there the description of a single shell or coralline, or any reference to its existence, much less any endeavour to make use of it to identify our strata. Mr. De la Beche has, however, shown how

abundant they are in the calcareous beds and slates which are associated with the great Grauwacke formation of the county; and how important it is to acquire a knowledge of their localities and species, that a true judgment may be formed as to the character of many of our rocks. Mr. Peach, with an assiduity and talent which do him the greatest credit, has applied his little leisure, and availed himself of the opportunities afforded him, in the execution of his duties as a riding officer, to study and collect the fossils of his district, and has made great additions to our knowledge of these ancient records. I understand that he has sent a large collection of them to the museum of this society, but I have not yet seen them; nor do I know whether the great difficulty which we labour under in finding space to contain our treasures has not made it impossible to render them accessible.

When at Plymouth, at the meeting of the British Association, I heard with great pleasure the commendations bestowed by Professor Phillips on Mr. Peach, who, he said, had brought to light many new forms of those ancient remains with which he was till then totally unacquainted. So great had been the additions made by Mr. Peach and others to the catalogue of fossils of the older strata, that he intended shortly to prepare a supplement to his work (just published) on Palæozoic Fossils; that is, on the records of animal organization in its earliest forms. A copy of the part already published is on the table, and I beg leave to present it to the society. Connected with this subject is a large specimen now before you, brought from the Falkland Islands by Commodore Sullivan, in whose name I request that it may find a place in your museum. The rock itself corresponds very exactly with some specimens in your cabinet upstairs from the neighbourhood of the Malvern Hills, and the fossils contained in it are, I believe, of the same geological date. Some years ago, when I sent these specimens to the society, I supposed the rock in which the fossils are imbedded to form part of the old red sandstone, but Mr. Murchison's recent speculations have brought to light distinctions which were not then perceived, and this portion of the Malvern district is now included amongst his lower Silurian beds. Specimens from the Falkland Islands have also been submitted to Mr.

Charles Darwin, and referred by him to the lower part of the Silurian system. The fossil which greatly prevails in the specimen before you was found by Professor Phillips at South Petherwin, in the eastern part of the county. Its name is Spirifera calcarata, and it is figured No. 128 of his Palæozoic Fossils.

When at Liverpool, during the meeting of the Agricultural Association, I heard that a bed of the new red sandstone had been opened in a quarry, near Warrington, containing innumerable traces of the footsteps of that extraordinary animal, the Cheirotherium. A gentleman resident in that town has been kind enough to procure for me specimens, which I now present to the society, together with casts of some of the same fossils in the Museum of the Natural History Society of Liverpool. These footsteps were, I believe, first discovered near Dumfries; but Dr. Buckland, in his Bridgewater Treatise, mentions that similar traces had been also found in Saxony, and that the animal, whose passage over the soft sand they record, had obtained the provisional name of Cheirotherium. He says also that some fragments of bones were found in the same quarries, but, unfortunately, destroyed; so that nothing remained to guide the comparative anatomist as to the nature of the animal, except the print of his foot. Since Dr. Buckland wrote, the mystery which attached to this, the earliest quadruped of which geology has discovered any trace, has been in some measure removed by the researches of Professor Owen. That excellent man, of whose talents it would be presumption in me to utter one word of praise, has lately had under examination the bones of an animal evidently connected with these footsteps. Its physiology appears to have been most extraordinary; combining the characteristics of the Batrachian and Saurian families; but, like many of the reptiles of the earlier period, this great lizard frog, if frog it was, far exceeded in size any type of the same order now existing, and probably attained the length of five feet. The structure of the animal is most anomalous throughout; and formed the subject of a paper read at the Geological Society of London, in the course of this season, and was again brought before the public, at the British Association at Plymouth, in a Report on the Fossil Reptiles of England, by Pro-

fessor Owen. This report excited the greatest interest at the geological section, and I am happy to say that £250 was voted for its publication in a form separate and distinct from the general report of the meeting. It will thus become accessible to all, and will contain plates which could hardly be admitted into the periodical publications of the association. Before I quit this subject, I may add that Mr. Cunningham, in his letter of advice respecting the fossils and casts which he has sent, informs us that he has discovered, in the same bed which the Cheirotherium seems to have traversed, remains of a gigantic fucus, 26 feet long and 7 or 8 feet broad.

There remains but one topic on which I will trouble the meeting with any further observations. There is on the table a box containing models, by Mr. Sopwith, of certain portions of the coal district in the neighbourhood of Newcastle. At first sight these models may appear as toys fit only to amuse; but they are far otherwise. They are meant to expose, and actually do expose, to the eye, the operations of those two causes, to which, in great measure, may be referred the present configuration of the earth's surface, and subjacent strata—dislocation and denudation; and are faithful representations, according to a given scale, of certain portions of the Newcastle district, with the geological facts there really existing. It is true that these models exhibit only incidents belonging to a country containing coal, of which we have none. Still the subject is general. To the student in geology, a knowledge of the coal formation is quite necessary; and even to the Cornish geologist, studying a different and older country, the lessons there taught are by no means uninstructive. Those great and general operations of nature, which are often with us spread over a vast surface, and are with difficulty combined into an intelligible hypothesis, are, amongst the coal measures, displayed on a scale much more easily read and comprehended; and this, because in the coal formation the strata are thinner and more readily distinguished. The faults and heaves often lie within a small compass, and the denudations are sensibly portrayed by the outcrop of strata, which cannot be mistaken. In fact, the coal formation is to the geologist what the satellites of Jupiter are to the astronomer—an example of general laws compendiously set forth, which in one case operate over large countries, and in the other over immense orbits and through lengthened periods of time.

# THE TWENTY-EIGHTH ANNUAL REPORT OF THE COUNCIL.

ALTHOUGH the progress of the society during the past year has been unaccompanied by any of the great steps of advancement which have marked some of the preceding epochs of its existence, yet the Council have the satisfaction of reporting that the accessions to the collections have been of considerable extent.

It is a subject of regret that the contributions of our intelligent mine agents and miners, both to the Society's museum and to its transactions, have been unsually few. With a view to their increase, the liberality of the President, of E. W. W. Pendarves, Esq., M.P., and of William T. Praed, Esq., M.P., has placed at the disposal of the Council a sum to be distributed in premiums to such practical miners as may communicate to the Society during the ensuing year descriptions of any new, uncommon, or important facts which may occur in the course of their pursuits, attested by the agents of the mines in which they may be discovered, and which the Council suggest may be augmented from the Society's funds if the contributions shall appear worthy of it, and if accompanied by illustrative specimens.

The labours of Mr. Phillips, under the sanction of the Lords of the Treasury, have completed the description of the Cornish organic remains known at the time of his publication; and as, through the donations of Mr. McLauchlan, Mr. Garby, and, beyond all, Mr. Peach, the museum contains a large collection of those recently discovered, as well as some found twelve years ago by the Curator, it will now be easy to place them in stratigraphical order. Beside the donations in other years, Mr. Peach has now laid before the society a curious collection of organic forms which were yet unknown to us, accompanied by figures and descriptions. But the Council regret that the fossil geology of Cornwall is about to suffer by the removal of Mr. Peach to another part of the kingdom.

Mr. Gesner, the Government Geologist of Nova Scotia and New

Brunswick, has during the year contributed to the museum a valuable and interesting collection of minerals from the British North American Provinces; and Mr. Henwood has presented a series from the rock formations of all the British Colonies in that part of the world, and from most of the Northern States of the Union, which have supplied proofs of the existence of an extensive Silurian system in the state of New York, and probably also in New Brunswick; those of the fossils which are new to British geologists will be described to the Geological Society of London by that accomplished and indefatigable geologist, Mr. Lonsdale.

A series of the metalliferous deposits of Ireland and of the Channel Islands now renders nearly complete the Society's collection from the copper formations of the United Kingdom, on which Mr. Henwood has been long engaged.

These, with the other yet unplaced stores which the society possesses, will more than fill every accommodation the present rooms afford; and it appears almost superfluous to commence an arrangement which another year's labour will require to be again disturbed. The Council therefore feel it their duty again to submit to the society the imperative necessity for additional space. They also desire to point out to the society and to the public that whilst this, the oldest scientific institution in the West of England, is without a habitation of its own, every one of the more recent establishments in Cornwall occupies its own dwelling. They confidently hope that an appeal will be made which shall provide this society either with a separate building, or obtain the concurrence of the other public establishments of the town and neighbourhood in the erection of an edifice which shall afford the accommodation which all of them so greatly need.

At the last annual meeting it was fully contemplated that the fifth volume of the society's transactions would have been completed in the course of the year; but the pressing professional occupations of the Curator have, for the greater part of the time, removed him from Cornwall; it may, however, be confidently anticipated that it will be finished early in the ensuing season.

By order,

W. J. Henwood,
Samuel Pidwell, } *Secretaries.*

*September 24th*, 1841.

# DONATIONS TO THE MUSEUM.

1. Sulphuret of tin, from the Carn Brea Mines; veins of tin ore in elvan, from Parbola Mine, and native gold, from Carnon Stream. By John Garby, Esq., associate of the society.
2. Stilbite, mesotype, jasper, analcime, thompsonite, chabasie, heulandite, apophyllite, laumonite, sulphate of barytes, zeolite, phosphate of iron, magnetic iron ore, oxide of manganese, lignite, amethystine quartz, agate, and other specimens, from Nova Scotia and New Brunswick. By Abraham Gesner, Esq., F.G.S., Government Geologist of N.S. and N.B., corresponding member of the society.
3. Native gold, and Jackotinga, from Brazil. By Percival N. Johnson, Esq., F.G.S.
4. A specimen of buck-stone, from Saugur Ghui Hill Fort, Bombay. By J. M. Davies, Esq., Hon. E.I.C.S.
5. Specimens of greenstone, with iron and copper pyrites, from New South Shetland. By Benjamin Bullocke, Esq,
6. Sulphuret of tin, from Carn Brea Mines; pseudomorphus oxide of tin, from Wheal Coates; and a fine specimen of copper pyrites in rectangular crystals. By Mr. Joseph Joseph, of Redruth.
7. Organic remains, from the limestone of Kerry. By Captain Stephen Thomas, of the Ardtully Mines.
8. Malachite, from Allihies Mine; and asbestus, from Blackball-head, County of Cork. By Capt. J. B. Reed, of Allihies.
9. Organic remains, from the slate rocks of Black-head, Mellendreth, Looe, Bodmin, and Polruan. By Charles W. Peach, Esq., corresponding member of the society.
10. Granite and greenstone, from Jersey; and granite, from Chauze, near Granville. By Richard Edmonds, Esq.
11. Specimens, illustrative of the conglomerates and raised beaches of the Lizard district. By the Rev. Edward Budge, vicar of Manaccan, member of the society.
12. A specimen of the fossiliferous rock of the Falkland Islands. By Commodore Sullivan, K.B.

13. Casts of the foot-marks of the Cheirotherium, and Sopwith's geological models. By Sir Charles Lemon, Bart., F.R.S., &c., president of the society.
14. A series of organic remains, from the silurian rocks of Lockport, State of New York, and from Dalhousie, County of Restigouch, New Brunswick; a series of specimens, from the rock formations of the States of New York, New Jersey, New Hampshire, Massachussets, and Maine, from Upper and Lower Canada, New Brunswick, Nova Scotia, and Prince Edward's Island; with specimens from the limestones of Meath and Kerry, and from the metalliferous veins in Meath, Cork, Kerry, and the Islands of Sark and Herm. By W. J. Henwood, C.E., F.R.S., F.G.S., Secretary of the Society, and Curator of the Museum.
15. A large specimen of quartz. By J. N. R. Millett, Esq., member of the society.

## DONATIONS TO THE LIBRARY.

1. Contributions towards a History of Swansea: by L. W. Dillwyn, Esq., F.R.S. By John Henry Vivian, Esq., M.P., F.R.S., honorary member of the society.
2. On Irish Tin Ore: by Thomas Weaver, Esq., F.R.S., F.G.S., &c., &c. By the author.
3. A Mineralogical Report on a portion of the districts of Mellore, Cuddapale, and Cuntoor: by Lieut. Ouchterlony, F.G.S., Madras Engineers. By the author.
4. Figures and Descriptions of the Palæozoic Fossils of Cornwall, Devon, and West Somerset: by John Phillips, Esq., F.R.S., F.G.S., &c. By Sir Charles Lemon, Bart., F.R.S., F.G.S., president of the society.
5. Proceedings of the Royal Society (1840–41). By the society.
6. Mining Journal from October, 1840, to September, 1841. By Henry English, Esq., F.G.S., member of the society, the editor.
7. Transactions of the Geological Society, vol. vi., part i., and Proceedings 1840–1. By the society.

8. Reports and Proceedings of the British Association for the Advancement of Science, for 1839–40. By the association.
9. Transactions and Proceedings of the American Philosophical Society. By the society.
10. Report of the Royal Cornwall Polytechnic Society, for 1840. By the society.
11. The ninth Annual Report of the Royal Horticultural Society of Cornwall. By the society.
12. Rules and Regulations of the College for Civil Engineers. By the Council of the College.
13. On the stratified deposits which occupy the northern and central regions of Russia: by R. I. Murchison, F.R.S., and E de Verneuil, mem. Geol. Soc., France. By R. I. Murchison, Esq., F.R.S., P.G.S., honorary member of the society.
14. Geology of the State of New York, 2 vols., 1839–40; 52nd Report of the Regents of the University of New York; Memorial of the American steam-boat proprietors relative to a legislative enactment. By W. C. Redfield, Esq., corresponding member of the society.
15. Letter to the Secretary of the United States' Treasury on steam-boat accidents: by W. C. Redfield, Esq. By the author.
16. Remarks on the Geology and Mineralogy of Nova Scotia, by Abraham Gesner, Esq., F.G.S., Provincial Geologist, corresponding member of the society. By the author.
17. First and second Reports on the Geology of New Brunswick. By Abraham Gesner, Esq., F.G.S. By the author.
18. "The Silurian System," an article from the Edinburgh Review. By W. H. Fitton, Esq., F.R.S., F.G.S., &c., honorary member of the society.

# TREASURER'S ACCOUNT.

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# TRANSACTIONS.

## *On the Conglomerates and Raised Beaches of the Lizard District.*

By THE REV. EDWARD BUDGE,

MEMBER OF THE SOCIETY.

THERE are two subjects of much Geological importance in the neighbourhood in which I reside, which have not, I think, been examined so fully and attentively as they deserve. The first is the Conglomerate formation, which occurs so largely in the eastern angle of the Lizard district, to which Mr. De la Beche has just glanced in his Geological Report, but without entering into any of those details which are so necessary and interesting to the student; and without which no accurate opinion can be formed. The second subject to which I allude, is that of the Raised Beaches, of which we have some fine examples in the adjoining coast. Having had frequent opportunities of examining these formations, I venture to lay before the society the result of my observations, which, if they should be the means of thus calling the attention of any who have witnessed similar formations in other places, and of inviting the researches of more skilful observers, will not have been entirely useless.

In taking a starting-point to observe the conglomerate referred to, it should be first viewed on the northern side, a little way below the Nare Point. The floor of the beach is in one or two places composed entirely of it, and large masses of it are lying about in all directions. It also forms a portion of all the cliff that is

visible as far west as Gemerra, about the distance, I suppose, of a quarter of a mile. Here it is seen rising above the cliff, taking a south-westerly direction, and occupying a position between beds of argillaceous slate on one side, upon which it rests, and a vein of quartz on the other, having a similar direction, and which may be traced from the Nare across the parishes of St. Anthony and Manaccan, in the direction of St. Martin's, and towards the quartz formation of Helston Downs. The coast being here low, the conglomerate does not rise in any place above the high-water line, and must therefore be viewed when the tide is out.

It takes at this place the form of a coarse but firmly-cemented aggregate, the fragments of which for the most part consist of rolled pebbles of various sizes, and of different colours, which give the rock a mottled, and at times a beautiful appearance. Hornblende, schist, quartz, red sandstone, and greywacke, both in its solid and slaty forms, constitute the material of this stratum, which is cemented apparently by a ferruginous sand.* Further towards the Nare Point, or the low and sharply terminating ridge of rocks which forms the eastern angle of this district, it is met by argillaceous schistus, of which that point itself is entirely composed. Its position seems to be above the slate, as it forms the steep bluff headland known as Pennare Point. In this more elevated spot, as in all such cases, the rock assumes a texture much more close, hard, and compact. Its grain is altogether finer, and it much more resembles some varieties of greywacke. Lower down on the southern side, and at the base of the cliffs—at a point termed Carnmere—the conglomerate again assumes its more striking characteristics. The whole substance of the rugged cliffs, when the tide retires, presents nearly the same striking appearance of rocks once reduced to fragments and re-consolidated.

There is here a fine section of the cliff exposed, and a purplish coloured slate † makes its appearance in a very contorted state, seeming as if it rested on the conglomerate; but I believe this appearance is deceptive, as in all the cases that I have seen on the opposite side of the promontory, the conglomerate is evidently

* See specimens Nos. 1 to 5. † No. 6.

uppermost; and the appearance at this spot may be explained, by supposing that it is merely an overlapping of the argillaceous schistus. From Carnmere the formation is continued in a modified state, and skirts the shores towards Porthalla for nearly half the distance between the two places. It then seems to be succeeded by a formation of dark grey argillaceous schistus, hard, and full of quartz veins, which do not seem to have a continuation further inland. Here we must retrace our steps, that we may follow the line of the conglomerate on the northern side of the Nare promontory. After some alternations near the line of its junction with the slate (which is evidently a continuation of the rock that occurs in Mawnan cliffs, on the opposite side of the bay), we see it again finely exposed on the face of a low cliff on the western corner of Flushing Cove. This cliff, being always easily accessible, except when high tides cover it, and being almost reduced by the attrition of the waves to a flat and tabular surface, offers an advantage for viewing it which some other localities do not. It is here composed of larger pebbles than ordinary, and has all the appearance of a loose beach turned into a solid pavement. From this point the line of this formation is almost continuous along the southern shore of the estuary. Throughout this extent, which is more than a mile, it puts on a variety of appearances, changing from a coarsely-grained or arenaceous mass* to one of finer composition, and at intervals its appearance is but little different from slaty or compact greywacke. One circumstance will however, I think, generally serve to distinguish it—the manner in which it splits, or its cleavage, which is more or less angular, instead of being laminated and regular, like the beds of the schistose series.

It should be observed that the headland known as the Little Dinas is composed entirely of argillaceous slate, which continues on the north bank of the estuary for a short distance from St. Anthony's church. Here the conglomerate commences again, and very instructive sections may be had of it on the low cliffs on either shore. From the village of Carne, which stands at the head of the estuary, it may also be traced on both of the acclivi-

* Nos. 7, 8, 9.

ties of the deep gorge or valley which separates the parish of Manaccan from that of St. Anthony. It is most distinctly visible however on the Manaccan side. There is a quarry of it opposite Tregonwell mill, and from thence, ascending the hill towards the village of Manaccan, there is a large section of it laid open by the road-side, where it exhibits the appearance of a loose mass of clay and marl, more or less indurated. On approaching the church-town we find the formation assuming somewhat of the aspect of a variety of trap.* Greywacke and quartz appear to be more sparingly diffused in it; and on the glebe, talcose schist, sometimes with a greenish tint, abounds. Its course appears to be north-westerly, but its boundary in this direction is not, I believe, clearly definable. I imagine, however, that it meets the commencement of the serpentine and hornblende district somewhere in the direction of St. Martin's bridge, which is in the road to Helston. If, however, we follow it from Tregonwell mill, which lies at the foot of the hill leading from Manaccan to St. Keverne, we find it winding its way along the southern sides of the valley. Near Trevurgy mill it becomes very conspicuous, large masses of it being visible on the sides of the slope. These are a true trappean conglomerate, consisting of lumps of a compound of horneblende and felspar loosely aggregated by earthy and ferruginous matter.† Throughout its course, as it removes farther from the sea-coast, it loses by degrees its arenaceous aspect, and becomes a rock of more simple structure. Its cementing matter is homogenous with the material of which it is mainly compounded. Its fragments are angular, and do not appear to have been rolled, but rather to have been re-united very shortly after the substances of which it is composed were crushed or broken up. It seems also evidently to have been derived from the great hornblende formation of the vicinity; and its course may be traced almost so continuously from that of the Nare, that we are constrained to pronounce it to be of the same date. Its difference of character and aspect may perhaps be accounted for, if we suppose that the materials of that at the Nare had

* No. 10. † Nos. 11, 12, 13.

been for some time in a loose state previously to their consolidation, and thus more powerfully subjected to the rolling action of waters than those could be which were broken up the latest, and the soonest re-united. Little doubt can, I think, be entertained that these conglomerates are part of a great system, and that they are, as Mr. De la Beche has supposed, the continuation of those at the Nare Head, near Veryan. That they were produced at a period subsequent to the formation of the argillaceous slate, quartz, and hornblende-slate, is apparent from these rocks entering so largely into their composition. From their extent we may also infer that they were the result of causes that operated simultaneously and powerfully over a wide tract of country.

Mr. De la Beche has suggested that these conglomerates might have been produced at or about the period when the serpentine rocks were protruded, or perhaps a little earlier, as there are no fragments of that formation discoverable among the imbedded portions of this aggregate at the Nare. He admits, however, that as the drift of pebbles might not be in this direction, such an opinion is not entirely conclusive. A fact that has lately come under my own observation would, I think, have modified his views on this subject; for I have obtained a specimen from the parish of Mullyan of a conglomerate which occurs there in loose masses, the basis of which is serpentine cemented by calcareous matter.* And in Bellurian Cove, which is less than a mile distant from the spot where this was obtained, there is visible at low water the extensive remains of a conglomerate of a different basis, but of which carbonate of lime is the cementing material.† Unless this formation then be of later date than the one already described, we shall be compelled to consider the serpentine as a previously formed rock. The discovery of this rock in the conglomerate of Mullyan, and the absence of it from those of other localities, only serve to show that each has been derived from the older formations in its immediate vicinity. At the Nare, and in Manaccan, we might expect to find serpentine absent from the conglomerate; for the hornblende-slate formation is here much

* No. 14*a*. † No. 14*b*.

nearer than the former rock, and as the drift of pebbles seems to have been rather from north to south than from west to east (judging from the way in which the boulders of sienite are disposed on Crousa Downs), no conclusion seems fairly deducible as to the comparative antiquity of the formations just referred to from the one not being found imbedded in the other. There are two curious facts, however, which seem to occupy so natural a place in connection with the origin of these conglomerates, that it will be necessary to refer to them here. The first is the accumulation of an immense bed of sand or gravel on the highest part of Crousa Downs, in the parish of St. Keverne. This spot is a remarkable one, as embracing one of the most extensive sea views in the Lizard district; and it is, perhaps, almost the only spot in this district where a view may be obtained at once of the Lizard lighthouses and that at St. Anthony, near Falmouth. In appearance it differs but little from the flat region of Goonhilly Downs, on which it borders. Its elevation above the sea is 360 feet, being within twenty feet of the highest land in the Meneage, which is Roskruge Beacon. On this comparatively lofty site we find an accumulation of beds of fine yellow gravel disposed in extended layers, and containing a quantity of rounded quartz pebbles. That the whole accumulation must have been brought here, and reduced to this state by the action of water, no reasonable doubt can be entertained. The only question which seems naturally to arise in visiting this spot is, how it has happened that such a mass should have been deposited in a place that is higher than the generality of the district? The other fact to which I would refer, as possessing an interest in connection with the mighty agencies of water, as developed in portions of the country traversed by conglomerate formations, is the singularly flat surface presented by a large portion of Goonhilly Downs, and the bed of clay which overlies the serpentine rocks.

If conjecture may be indulged on a region where there is so much that is mysterious, I would suggest that the sand beds of Crousa Downs may, perhaps, have owed their accumulation to the circumstance of there having been once some great chasm or crater existing in this locality—perhaps the orifice from whence the sienite

rocks of the surrounding plains and coast were erupted. It is a conceivable supposition that at the period when the ejection of these igneous rocks, as well as those of the trappean conglomerates, took place, such eruptions might be accompanied by immense torrents of mud and ashes. The latter would form the cementing portion of those rock aggregations in which hornblende predominates. The former, derived chiefly from the siliceous and aluminous strata, might have been thrown out on the surface of the Goonhilly district. If also we suppose that there was subsequently a rush of the ocean waters over this and all the surrounding localities, tearing up the surface of the rocks and transporting their detritus to particular localities, through the agency of currents, we can understand how, while the crater or hollow I have supposed was filled with the heaviest portions of the aqueous and turbid mass, a large portion of the lighter and more comminuted particles might be swept along, and at length settle down so as to form the wide and level plateau of the Goonhilly Downs. Whether many also of the deep coombs or valleys, which are so common in the Lizard district, might not have been scooped out at this period, is a conjecture that I deem by no means improbable. I think there is strong reason to believe that the estuary in this neighbourhood, which was, I have no doubt, at one time filled with the conglomerate already described, owed its origin to some such cause. On both sides the formation may be traced almost continuously, lining its sides to within a short distance of the mouth of Gillan harbour. A loosely aggregated rock, such as this is, which is even now continually crumbling beneath the action of the tides, would be easily swept away, or channelled out; and it is a remarkable fact that the windings of the valley seem to follow, almost with exact precision, the course of the conglomerate, until we reach the hornblende-slate formation. Whatever conclusion we form on this subject, whether we carry back our ideas to the days of the Mosaic deluge (and surely it is not easy to imagine a more adequate cause), or whether we ascend to a remoter period, it is evident that some vast disruption or debacle is necessary to account for the manner in which the sienitic boulders of Crousa Downs are tossed about in the wild disorder which they now exhibit on the hills and cliffs in the vicinity of Coverack, and from

that point upwards, as far as the Manacle Point. Upon the whole, then, I think it is impossible to take even the most cursory view of the conglomerate rocks, as they present themselves in the localities to which reference has been made, without being convinced that the period in which they acquired their present condition was one of great disturbance and devastation; and that we have in these a standing memorial of some of the most violent and tumultuous changes to which our globe has been formerly subjected.

### *The Raised Beaches.*

Closely connected with the formation just described, at least in point of locality, if not in antiquity, are the Raised Beaches, of which this part of the Lizard district exhibits many striking examples. They have not hitherto, perhaps, obtained all the attention which they merit, although Mr. De la Beche, in his Report, has casually noticed some of them. One of the most remarkable of these may be seen at Coverack. It occurs on the northern side of the Cove, at a little distance below the mill, and consists chiefly of large rolled pebbles arranged in very regular lines. Above, there is a thick capping of fine ferruginous sand, some of which is hardening into a stony mass, like the blown sand near Bude, on the north coast. Over this there is a bed of reddish-coloured marl or rubble: the sand and marl extend to the height of about twelve feet above the ancient beach, which is nearly five feet above the present high-water mark.

This specimen of a raised beach is an object of great interest, situated as it is in a large open cove, of easy access, and exhibiting a continuous section, for more than a hundred yards, of this ancient formation. Its position also is singularly striking, as it occupies a place, nearly at the extremity of that line, where rocks of diallage and saussurite intermixed, exceedingly beautiful and curious, are spread over the shores, at the foot of a highly picturesque village.

Beyond Porthalla, another good specimen of a raised beach occurs on the line of coast leading to the Nare. This commences at Nelly's Cove, which is about a quarter of a mile from that village. Mr. De la Beche has given a drawing in his Report, which conveys

a good idea of it; but he has not mentioned that this beach is continued for some hundred yards beyond this point. It however has the disadvantage of being accessible only at low water, and portions of it are seen, in some places, resting on steep ledges of rock still overflowed by the tide—a circumstance that seems to argue that the beach once extended itself over these as a platform, and that a considerable line of the rocky shores have here been abraded and washed away. This beach is interrupted by the rugged projections of the coast, but appears again at a short distance from the Nare, a little below Carnmere.

The most continuous and extensive sections of a formation of this kind in all the Lizard district, are to be seen on the northern side of the Nare point; with little interruption it may be distinctly traced for several hundred yards. Its elevation is, on an average, about five feet from the high-water level. The capping is a red marl, somewhat resembling that at Coverack, but of a deeper colour,* and containing fragments which in many specimens are not unlike the red sandstone formation near Plymouth. At one place this stratum of fragmentary *débris* rises from eight to ten feet above the ancient beach; and it appears to have a continuation at a considerable distance from this shore. Another section of it may be discerned at the back of the Pen-nare farm-house, which stands about midway in going across the promontory. At Carnmere it passes distinctly into the form of slate. That this stratum, allied, as it would seem, to the red sandstone formation, must have existed prior to the conglomerate, is evident from the fact that it is contained in considerable quantity in that compound, and it seems in some instances to be blended with the greywacke, giving it a curiously striped or ribbon-like appearance.†

One circumstance particularly observable in all the raised beaches that I have noticed, is the perfectly horizontal character which they preserve throughout their course: they seem uniformly to keep a line of direction parallel with the existing beaches on the shores below them. From hence it may be inferred that the relative changes in their position with respect to the sea—whether

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* No. 15. † No. 4.

they have been raised above their ancient level, or the sea has retired from them (which I consider the most probable)—was not produced by any convulsive movement; and also that the strata on which the beaches rest have not since been exposed to any violent action, or the beaches would not have retained their parallelism, but would have been displaced from their present position.

With respect to the fragmentary *débris* accumulated on the raised beaches, the mass which rests on those at the Nare, and at Coverack, judging from the perpendicular sections exposed, varies from six to twelve feet in thickness. Mr. De la Beche has given a figure to illustrate this, as seen at Nelly's Cove, a little to the north of Porthalla. He supposes it to have arisen from the giving way of the hill above; and adduces it as a proof that the kind of cliff which rose behind the ancient raised beach, was similar to that which now rises above the present. The same observation will apply to the others which have been noticed, with the exception, that as no cliffs rise behind them, the mass of angular fragments and clay with which they are capped must be considered, either as the ancient cliff in a state of decomposition, or as a portion of that diluvial detritus which has been spread over so large a portion of the earth's surface. The first conjecture seems to me the most probable; since a mere mass of diluvium would probably have consisted of the detritus of a great variety of rocks, whereas these fragments are mostly of one description.

Whatever conclusion we may arrive at respecting the origin of these monuments of our former shores, it may not be uninstructive to mark the extent of the changes which they have already sustained, and are likely yet to undergo, by the undermining action of the waters of the sea. The progress of time is silently marked as by an index, in the extent of waste and injury produced by their encroachments.

At the Nare, the waves have hollowed out a cavern of at least 100 feet in length, and from the sinuous nature of the shore at this place, we may now walk at once along the modern beach, and under the ancient one, which looks almost like a solid arch of masonry overhead, from one end to the other. I have observed a similar

instance of a cavern thus excavated under the old beach, not far from Nelly's Cove already noticed. But this at the Nare is a singularly beautiful one. The exudation of the red matter from the sides of the rocks imparts a highly coloured tint to the confervæ with which they are overspread, producing the effect of a brilliant tapestry of scarlet damask.

Another instance of the progress of the work of destruction has occurred within only a few months. Through the undermining action of the waves, a large mass of the superincumbent bed has fallen in, and nearly filled up one of the caves at the Nare; but the raised beach still stands like the arch of a bridge in front of the sunken cliff, as if to show the firmness of the cement by which the pebbles and sand of which it is composed are held together. Judging from the wreck which has already taken place, it is hardly to be doubted that a few hundred years will abundantly suffice to obliterate all traces of the portions of raised beaches that still exist, and to sweep away from our cliffs these interesting and curious relics of the sea's ancient boundary.

*An Account of the Fossil Organic Remains found on the South-east Coast of Cornwall, and in other parts of that County.*

By Charles William Peach, Esq.

CORRESPONDING MEMBER OF THE SOCIETY.

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It is about five years since the Fossil Organic Remains of the south-eastern coast of Cornwall first attracted my attention, and I have from time to time sent short communications to the society on the subject; but as I am likely soon to be removed from my present station, I now send a sketch of all the fossil remains which I have hitherto observed in this county, and the localities in which they have occurred, accompanied by specimens. The nature of my occupation has been such as to prevent me from taking more than hasty glances at the different points whilst attending to my official duties. I have therefore scarcely more than skimmed the surface; but, from the little I have seen, I have no doubt that a rich harvest will attend the experienced geologist who has time and opportunity to study the rocks carefully. From the resemblance which I have observed in the quartz rocks near Helstone to those which in other parts of Cornwall have been found to contain fossil remains, I am of opinion that they are fossiliferous, and I regret that I cannot visit and examine them. I have found fossils similar to those of Cornwall in the slates on Meadsfoot sand, near Torquay, and in the cliffs between Paignton and Brixham, in Devon.

In the sketch which I propose to give, I shall commence with the most western point of the coast, and proceed eastward.

*Cairn, Gerrans Bay (Parish of Veryan); Diamond Rock, near Caerhayes, Great Cairn, Great Peraver, near Goran Haven (Parish of Goran).*

In these places the quartz rock containing organic remains runs in a tortuous course almost in an E.N.E. and W.S.W. direction:

it frequently shows itself by large upbreaks, and may be traced in its course by scattered blocks. At its outcrop in the face of the cliffs it is shaken and rent in all directions, often appearing to have been broken into small pieces and afterwards re-united, forming an interesting breccia, the whole traversed by beautiful veins of milk-white quartz. The fantastic forms into which it has been thrown in various directions, show that it has been acted on by some very powerful force: it is occasionally micaceous, and speckled with oxide of iron; and in its various colours, as well as its hardness, mineral contents, and organic remains, it is much the same in all these places. It frequently encloses beautiful transparent crystals of quartz, as well as large opaque ones, and at the Great Cairn it affords specimens of iron ore. The organic remains are rather rare, and have hitherto been found only in the lowest parts, at the foot of the cliffs. The original matter of the shells is destroyed, and the space they formerly occupied coloured red, and frequently filled with a dusty oxide of iron; but the markings are well-defined, and the shells they represent appear to have been deposited in layers, showing the stratification of the rock; and notwithstanding the rock must thus have been formed under great pressure, and the shells suffered great smashing, they are not so much injured as might have been expected. Some of them are parted by the cracking of the rock, and the space filled up by a white vein of quartz, the parts of the shell being *heaved*, illustrating the manner in which mineral veins have been thrown out of their course. The organic remains yet discovered are all bivalve shells, evidently belonging to the great *Terrebratulite* family: they are nearly alike in all the places, differing slightly in size, being smaller at the Cairn in Gerrans Bay than at Caerhayes or Great Peraver.

### *The Van, near the Black Head.*

In the Van, organic remains are found in calcareous slate in immediate contact with a greenstone trap dyke, which has discoloured the slate and the organic remains at the junction. In addition to *Encrinites* and *Corals*, may be mentioned a *Cyathocrinus*, with *Spiriferæ* and other mutilated bivalve shells. *Encrinites*

are plentiful, especially in the rocks between low and high-water mark, which are very calcareous. Corals and the other fossils are rare: the light colour of the fossils forms an interesting contrast to the dark-coloured matrix.

Between this place and the Slate Quarry a very fine specimen of *Orthoceras* has been found.

### *Slate Quarry, near the Black Head.*

Proceeding eastward, fossils are again met with in the Quarry near the Black Head, formerly worked for roofing slates; and a very interesting series they are, comprising beautiful and delicate *Corals;* the impression of a rope-like *Encrinite*, and many other singular *Crinoidal* remains, with *Turbinoliæ*, the latter rare; also very faint impressions of bivalve shells. The slates are cut through by the Trap dyke which passes from the Van through the Black Head. From hence to Rope Haven, *Crinoidiæ*, *Turbinoliæ*, and *Corals*, are sparingly met with.

### *Porthpean.*

In the cliffs on the eastern part of the beach are *Encrinites*, in a light-coloured slate, so ill preserved as to render it difficult to make them out.

### *Charlestown.*

A few minute and ill-defined *Encrinites* are to be seen in the rocks under the Battery.

### *Apple-tree Cliff.*

From Charlestown to Apple-tree Cove a few remains of well-defined *Encrinites* are to be found, some of them large; and what renders them particularly interesting, they are almost in connexion with the copper lode which shows itself in the face of the cliff.

### *Spit-point, Parr.*

At Spit-point, Parr, small but well-defined *Encrinites* are sparingly met with, in a friable dark-coloured slate, below high-water mark; and to the westward of this spot, at Gull-rock Cove, I found a very beautiful specimen of *Turbinolia*, now in the Museum of the society. Crossing the Harbour, *Encrinites* and very interesting and singular *Corals* are found in a soft light-coloured slate, but they are not well defined.

### *Polkerris.*

On the beach, below the inn, *Encrinites* and *Turbinoliæ* occur in a lead-coloured slate, which continues to some distance westward. The same fossils also occur, in a singularly contorted and finely laminated slate, in which light and dark layers alternate. At the back of the pier, the slates enclose black lozenge-shaped masses, evidently of organic origin, but so much defaced that nothing satisfactory can be made out of them.

### *Gribbon to Pridmouth.*

In tracing the cliffs under the Gribbon, *Crinoidal* stems and detached vertebræ are sparingly met with, and also faint traces of shells. At Pridmouth, near Menabilly, I found a fine specimen of *Platycrinus*, with the column, pelvis, arms, &c.; also, in nearly vertical strata of exceedingly friable dark slates, minute stems of black trumpet-shaped *Crinoidea*, which fall to pieces in removing: they are numerous, but confined to one narrow spot. A short distance from them, remains of shells, corals, &c., are plentiful, in a brownish coloured arenaceous slate, but so indistinct as to render it impossible to get any good ones. The strata here are much disturbed. Below high-water mark, the recent *Pholas dactylus* is very plentiful, which shows either the presence of lime in the rocks, or their extreme softness. I incline to latter opinion.

*Fowey Harbour.*

The hill at the entrance of the harbour contains organic remains.

*Ready Money Cove.*

Near the lime-kiln I found *Turbinoliæ*, casts of bivalve shells—probably *Spiriferæ*, and also stems of a peculiar *Encrinite*, with very thin joints, having a groove running down the whole length: the strata are so arenaceous and friable, that it is a difficult matter to obtain good specimens. The cliffs along the harbour from this spot are fossiliferous, containing joints of *Crinoidea* and *Orthoceratites*, with large *Turbinoliæ* occasionally, especially under the cottage near the castle: the slates there are light-coloured, and traversed by quartz veins of a dark colour, which, with the fossils, are in relief, from the soft slate being weathered away. Nearer the castle the fossils are more abundant, particularly *Encrinites*, which, in some places, give the rock a porphyritic appearance. Some of the *Encrinites* are very large, as are also the *Orthoceratites* found there. There is one description of large *Encrinite*, which is rarely met with, which has the divisions formed of four or five thin plates which close at each end, and when a longitudinal section is shown, appear of a lozenge-shape: each plate is delicately striated on both sides, radiating from the centre. This was found in a bluish slate, in which is a great deal of calcareous matter. Here are also portions, possibly of fishes, and a Coral, like *Favosites*.

*Between the Castle and White-house Ferry.*

The fossiliferous beds here are contorted and bent in a singular manner: at one spot they form a series of vertical-sided arches; a little farther on, this is reversed: beyond this they are inclined at an angle of about 45° resting against strata perfectly vertical, the whole mixed with arenaceous beds, sometimes cemented by a black oxide of iron: occasionally a bluish hard rock is met with, highly calcareous, effervescing freely with acids, from the abundance of the organic remains. Near the ferry, in vertical strata, are great

quantities of shells, *Spiriferæ*, &c., of a red colour, in a light-coloured friable sandstone; small *Encrinites*, and several sorts of *Favosites*, are also in great abundance. The arenaceous slates here are exceedingly fossiliferous, abounding in joints of *Crinoidea;* but owing to the hardness of this rock, from the oxide of iron, and its breaking in every direction, it is not possible to obtain good specimens.

*Quarry near the Rope-walk.*

The fossiliferous beds are in thin seams in the upper part of this quarry. The fossils are rather abundant; but owing to the softness of a great deal of the rock, good and perfect specimens are rare. In addition to beautiful and delicate *Corals*, by no means plentiful, may be mentioned an *Encrinus*, also rare, which resembles the *Stag's-horn Encrinus* of Miller, figured in Parkinson's Organic Remains, vol. ii. pl. 13, fig. 75 and 76; beautiful *Turbinoliæ*, of different sizes; an elegant *Orthoceras*, the siphuncle large. This fossil appears to be like the *Actinoceras* figured in Lyell's Elements of Geology, p. 463, as found in Lake Michigan, in North America, and at Castle Espie, in the county of Down, in Ireland; also the impression of a *spiral shell (Terebra?)*; a singular specimen, very much like *Cololite.*

The rock on the side of the Rope-walk is also fossiliferous.

*Polruan, St. Saviour's Quarry.*

Here the fossils are not numerous: the most abundant are *Encrinites.* Very large and interesting *Favosites*, as well as smaller ones, and splendid and large *Turbinoliæ*, are also sparingly found. The fossils are in thin seams in a decomposed stone.

*Quarry, near the Castle, back of the Coast-Guard Station.*

*Turbinoliæ* and *Encrinites* are found here.

*Punch's Cross Quarry.*

Here fossils are abundant, especially *Encrinites;* very large and beautiful *Favosites*, some a foot in length, as well as small ones; *Spiriferæ*, *Productæ*, *Terebratulæ*, and several other shells; *Orthoceratites*, an *Amplexus* (?), portions of fishes, pieces of bone, specimens having very much of a plant-like appearance, portions of *Trilobites*, and remains also of a fossil the structure of which resembles *Sepiadæ*.

These rocks have been quarried for economical purposes, the beacon of the Gribbon being built with the stone from this quarry. Although fossils are met with in almost every part of it, they are most abundant in the upper part of each bed, so much so as to render it unfit for use. They gradually diminish towards the lower parts of the beds, so that in some parts the trace is nearly lost. This is the case in the whole of the beds which have a gentle inclination, and are not contorted.

*Cliffs near the Flag-staff, and Eastward.*

The fossiliferous beds appear again round the point east of the harbour. In the upper part are *Crinoideæ* in great plenty, mingled with lozenge-shaped masses, which may possibly be the heads of these interesting fossils; also *Turbinoliæ*, *Favosites*, with portions of shells, *Trilobites*, and probably *Sepiadæ*. In some parts the strata are highly inclined and very much contorted, and generally of a dark slate-colour. Eastward of the flag-staff they are of a brownish colour, highly inclined, beautifully curved, and fall from the cliffs in interesting masses, showing to advantage the relics which they contain.

*Barcelona Quarry, between Pelynt and West Looe.*

In the quarry on the right of the road near Barcelona ill-defined *Encrinites* occur in a brownish-red rock, in which is a great quantity of quartz.

### *Quarries at the head of the New Road near Port Looe, and the Rocks on each side leading to West Looe.*

Near Port Looe, in a stratified, grey-speckled, hard rock, an equivalved bivalve shell, very much resembling a *Nucula*, with *Terebratulæ* and *Encrinital* remains, are found. *Encrinites* also occur in a quarry near the residence of Captain Walcott, R.N. The quarries at the head of the new road consist of a hard quartzose red or pink rock, traversed by small quartz veins. Here beautiful bivalve shells, evidently *Terebratulæ*, occur, with abundance of *Encrinites*, *Cyathocrini*, and other shells; the *Cyathocrini* are large and beautifully marked, the space they formerly occupied being filled with a bright-red ochreous earth. The impressions of the bivalve shells are peculiarly interesting, from their strong markings, the sharpness of the angles, and the whole being covered with dark minute crystals of quartz, giving them a serrated appearance. The greater part of the strata which have been exposed by the cuttings on the new road are composed of a friable arenaceous rock, which contains fossils agreeing with those found in the cliffs at East Looe.

### *Cliffs from West Looe to Port Netley.*

The cliffs on the west side of the Looe are fossiliferous; but on proceeding west they become much less so, very few indistinct *Encrinites* being found from thence to Port Netley. Rolled stones, containing specimens similar to those from Port Looe, are by no means uncommon. The rocks for the greater part of the way have been cut down, almost to the level of the beach, in order to make a large slip; the parts that remain are in great confusion, and much contorted.

### *New Road, Common Wood, and Bank along the River, West Looe.*

In the rocks exposed in Common Wood by the cutting of the new road from East Looe to Torpoint, interesting *Encrinites* and *Cyathocrini* are found, agreeing in every respect with those found

in the quarries near Port Looe, and embedded in a similar matrix; the bivalve shells are rather more plentiful, and differ a little, being coloured brown. In these cuttings a great many beds of limestone are exhibited, in which are innumerable indistinct portions of (probably) *Encrinites.*

*Road by the side of the River leading to Morval.*

On the side of the road leading to Morval, on the banks of the East river, the rocks are fossiliferous; veins of limestone are intermingled with the slates. At Steps, in a quarry about a mile and a half north of East Looe, *Encrinites* are found in a friable arenaceous stone, in thin seams, between the beds quarried for economical purposes.

*East Looe, Guns Hill.*

In the hill, called Guns, on which East Looe stands, I have found the most interesting and splendid Cornish fossils I have ever met with. Here is a rich mine indeed, which will afford a treat to those who delight in fossil geology. The matrix is a light-coloured quartzose rock, occasionally stained red, and spangled with minute crystals of quartz. At the foot of the cliff are immense quantities of *Encrinites*, as well as impressions of large shells, with *Turbinoliæ*, *Favosites*, *Fenestellæ*, &c. &c. A short distance from this spot, on the same level, is an inclined, soft, brownish rock, full of fossils similar to those last mentioned. Ascending the hill, the rock becomes more friable and arenaceous, and of a brownish-red colour; here it is extremely rich in fossils, *Spiriferæ*, *Productæ*, *Fenestellæ*, *Favosites*, &c. &c. On this spot I found one of the finest specimens of *Encrinite* I ever saw, a part of the column of which is tubercled. It has four auxiliary side arms—three on one side, one on the other; the *pelvis* peculiarly marked, something like the shield of a coat of arms, quartered and spotted; several of the *tentacula*, with the *pinnæ*, beautifully developed; and the extreme end of one of the *tentacula* has its head turned something like the recent *Pentacrinus caput Medusæ* noticed in Buckland's

Bridgewater Treatise. In the upper part of the hill fossils continue plentiful, in a soft arenaceous stone, intermingled with the slates, in which are exceedingly minute delicate corals and shells. Near the sea wall, against the parade, is a hard red rock, traversed by quartz veins, *Encrinites, Corals, Terebratulites,* &c. &c. abound.

### *From Guns to the Chough Rock.*

Taking an easterly course, before reaching the Chough Rock *Crinoidal* remains are abundant in the cliffs—some of them white, in a dark matrix; in some of the blocks they are reddish, in a brownish-grey slate.

### *Chough Rock to Pleida.*

In the Chough Rock, and from thence to Pleida, similar fossils are found. At Pleida the *Encrinites* and *Turbinoliæ* stand in relief from the matrix, which, being softer than the fossils, is weathered away. Here stems of a *Cyathocrinus*, in a dark grey wavy slate, with several consecutive vertebræ, and also very interesting specimens of (probably) *Cyathocrinus nodulosus* are found. On the west side of Pleida is a red rock containing abundance of *Encrinites*, with a few *Cyathocrini*, similar to those in the rocks of Common Wood, which are evidently a continuation of the same beds.

### *Mellendreth.*

On the west side of Mellendreth, under the lime-kiln, *Encrinites* are plentiful; *Turbinoliæ* rare. After passing this point of rock, fossils become abundant in an arenaceous friable schist, *Encrinites, Turbinoliæ, Orthoceratites, Favosites, Productæ,* and *Spiriferæ,* with a great variety of other shells; in fact the whole of the rocks appear to be completely full of organic matter. The cliffs from this spot to a little beyond Seaton river contain very few fossils; the strata are very much contorted—a great portion in ruin and

confusion, from a large landslip. In the rocks between East Looe and Mellendreth, patches of limestone occur in the cliffs, containing immense quantities of *Encrinites* and other organic remains; from its hardness, and being susceptible of a polish, I have named this stone *Cornish Entrochal Marble.* The limestone appears in the whole of the slate in the vicinity of East Looe; there are also large blocks of crystallized carbonate of lime, red, white, and grey, scattered on the beach, and in the cliffs, as well as in the rocks on the river side: these blocks are solid, and would take a most excellent polish, and might be cut into slabs for tables, or used for other ornamental purposes.

### *Bodmin.*

In the quarry on the hill behind the Assize-hall, *Encrinites*, both round and elliptical, occur; small ones are abundant: they are in a grey wavy stone.

### *Menheniott, Tregrill Slate Quarry, Rose Vale.*

In this noble slate quarry a quantity of limestone is found, of a dark slate-like appearance; a kiln has been erected, and an attempt has been made to convert it into lime, but without success: it effervesces freely with acid. In this limestone small *Encrinites, Turbinoliæ,* with *Trilobites,* are imbedded: these fossils, however, are rare.

### *St. Austell Stream Work, Pentuan.*

Here I have not observed any fossil remains, and as to the alluvium of Pentuan Valley, its contents have already been described in the Transactions of the society, by J. W. Colenso, Esq., I would therefore merely remark, that abundance of shells may be found in the refuse which has been thrown out in digging there; they agree in every respect with those at present found on this coast; the most abundant being of the description usually met with in estuaries.

*Port Mellin, near Mevagissey.*

At Port Mellin, after a heavy gale of wind which had scoured the beach very much, I observed the roots and parts of the stems of trees of considerable size, *in situ;* showing that this valley was probably once occupied by a forest. They were on clay, surrounded by alluvial matter, composed of flags, &c., in which were enclosed the *Elytra of Beetles,* retaining their primitive brightness. These do not belong to the general objects of this paper; still I thought them sufficiently interesting to deserve a passing notice.

In conclusion, I would apologise to the society for having been obliged to name and to describe the different fossil remains in the most general way; for little indeed has been the time which I have been able to devote to the study of fossil geology.

*On the Pseudomorphous Minerals found in Cornwall, illustrative of a replacement of one mineral substance by another.*

By JOSEPH CARNE, Esq., F.R.S., &c.

TREASURER OF THE SOCIETY.

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It is well known that every mineral body is subject to certain laws of crystallization, and when the primary or essential form of the crystal of any mineral substance is discovered, it is not difficult for an experienced crystallographer to ascertain all the other forms or modifications which the mineral can possibly take; all of which are connected, either immediately or remotely, with the primary crystal. When, therefore, the mineral is found crystallized in either of those forms, it is supposed to be in its natural state—crystallized according to its own law. But it occasionally happens that mineral substances are found apparently crystallized in forms which naturally, and by their own law, they cannot possibly take; and even when the crystals have the natural form, their fracture and cleavage prove that they are not the natural crystals of the substance. Such crystals are known by the term "Pseudomorphous"—false form or figure. It is, therefore, a very interesting enquiry, how they have become so crystallized, or, if not really crystallized, how they have become possessed of forms which are not natural to them, but belong to other bodies? The only general conclusion to which we can come is, that the minerals which now appear are not the same as those which the crystals first exhibited—that either a partial or a total change has taken place, by which they have become either different varieties of the same substance, or different minerals altogether.

Some apparent transformations of minerals, especially metallic minerals, are not at all uncommon, and are easily accounted for. A mineral substance—suppose sulphuret of iron—is decomposed,

and the sulphur is disengaged from the metal, and, uniting with the oxygen of the water, or the air, or both, becomes sulphuric acid, which, again uniting with the metal, under the influence, probably, of certain changes of temperature, sulphate of iron, or vitriol, is formed. Thus the sulphurets of metals may become sulphates. Copper in its metallic state, when exposed to the action of other bodies, combines in various ways with their elements. This was strikingly evinced in the copper coins found some years ago near the Hayle Causeway, on many of which the oxide, the carbonate, and the muriate of copper were very visible.

These changes, however, are not replacements; neither are the new crystals pseudomorphous. The new mineral has not the same form as the old one, but has taken its own form. They are not what it is principally intended to describe in this communication, and are alluded to here merely for the purpose of exhibiting the illustrative specimen on the table, in which the change actually occurred in my own cabinet. Some time ago I found a specimen of iron pyrites rapidly decomposing. I took it out of the drawer and placed it in the window. Perhaps three months might have elapsed before I noticed it again: in the mean time the rain had entered through the crevices of the window, and had run over the specimen, and when I next observed it, I found it covered with crystals of sulphate of iron, and the decomposition had entirely stopped.

Another change to which I shall here allude, on account also of the specimens which illustrate it (and which is indeed a replacement, although not of one mineral substance by another), is that which takes place in the petrifaction of organic bodies, especially vegetable and animal substances. Here the stony or other matter appears to be gradually deposited as the organic substance decays, until it acquires the precise form of the decayed substance. The petrified wood found in many parts of England, and also the petrified bones and other parts of animals, are so common, that their discovery occasions no surprise; but when the matter deposited is a metal, the singularity of the case gives it greater interest, although there is, in reality, no greater difficulty in supposing a deposition from a metallic than from an earthy solution. Of this kind are

the pyrites mushrooms, and other animal forms, of Dorsetshire; and there are on the table some small plants in native copper, so exquisitely formed, that not only are the stems and the leaves quite perfect, but the very fibres of the leaves are equally so. Indeed a good botanist might almost venture to give us the names and description of the plants. They were found in a copper vein in Treskerby mine. How plants could possibly have grown or have existed in such a situation, we may, perhaps, be quite at a loss to guess, yet it is not easy to account for the formation of these specimens in any other way, for if we apply to them the term *lusus naturæ*, we may use it with respect to all organic remains. There is another shrub-like specimen of native copper from Condurrow on the table, which, however, does not bear so exact a resemblance to a plant as to be classed with the former specimens.

The next class of pseudomorphous minerals to which I shall allude, is that in which the change or replacement of metallic ores appears to be caused by the loss of one of the constituent parts—that part by which the metal is held in the state of ore—and the acquisition of another. Thus in the change which frequently takes place in iron pyrites from the sulphuret to the oxide of iron, the original body seems to have lost, or been deprived of, its sulphur, and to have taken up oxygen and water, the form of the crystal not being in the smallest degree altered. Of this there are several specimens on the table from Levant mine, which are now oxide of iron, but whose crystals are the natural crystals of sulphuret of iron; such as the octohedron, the dodecahedron, the cube, &c. Amongst these specimens there are two in which the change is not yet complete, but appears to be still in progress. In one, the whole is oxide of iron, except two small spots on the edge, which are still sulphuret. The other specimen is highly illustrative of the progress of the replacement. It is a part of a large cubical crystal which, it is evident, could not have been originally as it now appears to us; as a crystal cannot naturally comprise two substances, unless they are in chemical combination; but here we perceive the sulphuret of iron cracked all over, and the oxide appearing in the crevices, and on one side, the interior seems to have become entirely oxide. Mr. Haidinger supposes that the change

begins at the surface and gradually penetrates the interior; but in this crystal one would almost suppose that the change had commenced in its very heart, and extended from thence to its external parts. In these changes there is no appearance of decomposition, but the mineral, retaining its solid state, seems to have gradually and imperceptibly passed from one combination to another. Yet it is impossible to say that some degree of decomposition may not have taken place, although almost imperceptibly: even the brown tarnish which sometimes appears on the surface of crystals of pyrites may be incipient decomposition.

A replacement of the carbonate by the oxide of iron has also occurred. As the iron exists in the carbonate as a protoxide, the mineral has only to part with its carbonic acid to become an oxide of iron. This appears to have been the case in the six-sided tabular crystals in the specimens on the table from St. Just, in which the carbonate and the oxide may be seen in similar crystals on the same specimen.

The prismatic crystals of sulphuret of lead, called blue lead, from Huel Hope, in St. Agnes, probably belong to this class. They appear to have been originally phosphate of lead, which is easily decomposed by sulphuretted hydrogen, even at the common temperature of the atmosphere; and the same agent which decomposes the phosphate may, by parting with its sulphur, form the sulphuret in its place. Where the crystals are hollow, the external part only has been changed, and the internal afterwards dissolved; but where they are solid, the change is complete. In one of the specimens on the table several stages are apparent in the crystals: some are wholly sulphuret; others show the sulphuret with an external coat of phosphate; others appear to be partly sulphuret and partly phosphate throughout, and a fourth variety are wholly phosphate.

The converse of this change sometimes takes place by the sulphuret of lead becoming carbonate and phosphate. A specimen on the table shows the carbonate of lead in cubes, a form which is not natural to it.

The next mode of replacement to which I shall refer, and which is perhaps of the most frequent occurrence, appears to have been caused by the deposition of one mineral substance upon the crystals

of another, and the primary substance having been afterwards dissolved, the deposited mineral remains externally in the same form as that which has been destroyed. These crystals (for so we must call them, although improperly) are, therefore, usually hollow. Illustrations of this substitution will be found in hollow cubes of quartz from Huel Spearn, and also cubes of chalcedony from Craft-an-Verth, both in St. Just, the siliceous matter of which was probably deposited on cubic fluor. Rhomboids of quartz from St. Just, of which the silex might have been deposited on felspar, or more probably on pearlspar. Dog's-tooth quartz, and hexagonal pyramids of quartz, both from Botallack, in which the deposition was doubtless on calcareous spar. Flattened rhomboidal quartz from Botallack, which appears to have been deposited on carbonate of iron. Tabular quartz from Huel Edward, which even now incrusts the oxide of iron. Octohedral quartz from North Roskear, perhaps deposited on iron pyrites.

It will probably have been remarked, that in these specimens the deposited matter is invariably siliceous.

It is possible for hollow crystals to be formed by a different process. Mr. Haidinger mentions an experiment made by Professor Mitscherlich, of Berlin, in which solid crystals became hollow, and a crystallized substance was formed within them by the application of heat. He exposed crystals of hydrous protosulphate of iron immersed in alcohol, to a degree of temperature equal to the boiling-point of that liquid. Decomposition ensued, although the external shape of the crystal remained unchanged. On being taken out of the liquid and broken, each of them was found hollow, and presented a geode of bright crystals of the same substance. I have no idea that any of the crystals here alluded to were formed by this process; but there is a specimen on the table which highly illustrates it. The crystals are oxide of iron; they are all hollow, and filled with small crystals of quartz. Supposing the crystals to have been originally siliceous oxide of iron, the origin of the quartz crystals is evident.

The last class of minerals which I shall mention as illustrative of replacement, consists of those whose crystals are perfect of their kind —quite solid and compact—but not being in the natural form of the minerals which they represent, were originally, in all proba-

bility, crystals of other minerals. Such are the solid cubical crystals of quartz from Huel Alfred, and also from Botallack, which were perhaps originally fluor: on the Botallack specimen is a crystal in which the accuminated angles, often seen in fluor, are perfectly preserved. The nail-head crystals and also tabular crystals of quartz from Botallack, probably at one time carbonate of iron. Hexagonal tabular crystals of chalcedony from Balleswidden, in two specimens of which may be observed the different stages of the replacement; in one, the chalcedony is merely deposited on carbonate of lime, which is everywhere visible; in the other, where the carbonate of lime is seen at all, the line of it is but just perceptible, and in some parts it is wholly gone, and the solid crystal of chalcedony remains. Octohedral crystals of chlorite from Roskear: the primary crystal of chlorite is a flat six-sided prism, a form quite opposed to that of an octohedron: the latter, therefore, is probably a replacement of some other mineral, although it is not easy to say of what mineral.

The beautiful crystals of copper pyrites from Huel Tolgus probably belong to this class. They are in a form in which that mineral has rarely, if ever, before appeared—that of an obtuse rhomboid, one of the natural forms of carbonate of iron, some of which is still perceptible on the specimen; and of this it may be reasonably supposed to be a replacement. Another specimen* exhibits copper pyrites in solid cubes, which have probably replaced cubes of iron pyrites. Here also, I apprehend, we must place the crystals of oxide of tin from Huel Coates, in St. Agnes, having the exact forms of the various crystals of felspar That the tin has here taken the place of the felspar can scarcely be doubted, as the specimens on the table exhibit the change in almost all its stages. It is probable, however, that previous to the replacement by the tin, the felspar had become decomposed, and by giving out its alkali had remained in the state of a sandstone. Here is first the crystal of felspar, or rather sandstone, partially decomposed; another crystal shows that the tin has just begun to invade it; in another, it has made greater progress; two others are nearly equally divided—one lengthwise, the other crosswise—in which one half

* Presented by Mr. Joseph, of Redruth.

is oxide of tin, and the other half felspar; in another, only a little felspar remains at one end of the crystal; and others exhibit the complete replacement, and even a new crystallization, of tin on the first crystal. In a broken crystal, the fracture, lustre, &c., are just as they appear in the common rich tinstone of our mines.

In another mine in St. Agnes—Huel Primrose—crystals of oxide of tin have been found having the exact form of quartz crystals, in which the quartz may possibly have been invaded by the tin. I say invaded, for it is not a complete replacement, as a part of the siliceous matter still exists in chemical combination with the tin, forming a siliceous oxide of tin.

The crystals of Haytorite, from Haytor, in Devonshire, are also generally supposed to be pseudomorphous. Dr. Brewster thinks it likely that datolite was the original substance, which contains more than one-third of its mass of silica, and that the lime and boracic acid have been exchanged for an additional quantity of silica, and thus the whole has been transformed into chalcedony. In the same class have also been placed the octohedral crystals of hornstone found at Beeralston, on the evidence of their internal structure.

In attempting to account for these replacements, some have supposed that they have all taken place by the deposition of one substance on the crystals of another, and that after the dissolution of the original substance had left the hollow coat or mould of a crystal, this was subsequently filled by a second deposition. I can only say, that in all the fractured crystals which I have seen I have observed no marks of such distinct depositions. Others have supposed that after these moulds have been filled, the moulds themselves have been dissolved, leaving the form of the crystals perfect; but the peculiar state and circumstances of some of the specimens which have come before us would rather lead us to contemplate the possibility of a replacement of a solid substance by a solid substance, probably particle by particle, or molecule by molecule, with very little, if any, of what we usually denote by the term decomposition, and without any alteration of form or figure; but in what manner this is accomplished we must yet c nfess our ignorance. The only agent which presents itself to our minds is electricity, which daily accumulating experiments teach us has had much to

do with the formation, the decomposition, the reformation, the replacement, and the various combinations of mineral bodies.

Had the subject been treated more generally, it would have been easy to accumulate facts to a much greater extent, such as the replacement of the blue carbonate of copper by malachite, and *vice versa*, in Siberia, and at Chessy, and of the oxide by the carbonate of copper at Chessy, and in South America; with many other instances, but it is intended to confine this communication to the replacements which may be illustrated by specimens found in Cornwall and on its borders.

It will also have been observed, that these remarks have been confined to cases in which crystallized bodies have come under our notice, and these are, in fact, the only bodies which will admit of proof of the change which has taken place; but reasoning from analogy, it will scarcely admit of a doubt that the same process has been in operation, and is constantly proceeding, not merely in separate crystals, but in immense amorphous masses, both of earthy and metallic minerals, in different parts of the globe. The change, for instance, from copper pyrites to sulphuret of copper in the metalliferous veins, which Mr. Fox's experiments have shown to be easily effected, furnishes an instance, probably by no means solitary, of the possibility of such a replacement.

*Some Account of the Porcelain Earth found in the kingdom of Saxony and the principality of Passau, and of the circumstances under which it occurs: collected from German publications.**

By the late JOHN HAWKINS, Esq., F.R.S., &c.

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In the two communications which have been made to this society on the subject of our china clay, I have stated with precision all the circumstances which I had opportunities of observing. These, taken collectively, have a strong tendency to reverse the prevalent notion of the origin of this friable rock, and of confirming the opinion which I ventured to express of its aboriginality. It is a question, however, of so much importance, that, should it ever be decided by the opinions of the majority of geologists in the way that I have pointed out, it must infallibly lead to some new views of the origin of many of our principal rock-formations.

That no means may be wanting to facilitate this decision, I have lately consulted all the information which has been published by the German geologists on the subject of a similar earth, which is employed as the basis of their principal manufactories of porcelain; the substance of which information I shall here communicate.

The first of these reports is drawn up by Mr. Oelschlagel, and printed in the year 1818, among the select papers of the Mineralogical Society of Dresden. It relates to the porcelain-earth, as it is called, of Aue, in Saxony, which has long been the principal material of the celebrated Dresden manufactory.

It occurs in a district of granite near Schneeberg, and in a spot where that rock assumes the form of a cone, the apex of which emerges through a mantle-like covering of micaceous slate. The porcelain-

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* This account was sent by Mr. Hawkins to the Society, in order that the circumstances in which porcelain-earth is found in Saxony, &c., might be compared with those in which it occurs in Cornwall.

earth lies beneath this slate in two beds, which are separated by a bed of granite. All the granite which composes the cone is in a very decomposed state, the felspar which it contains being *changed*, as it is supposed, into porcelain-earth.

The two beds of this earth vary in their thickness, as they extend horizontally from a few inches to three-fourths of a fathom, that of the intervening bed of granite averaging about one fathom; the greatest thickness of the three beds, which amounts to two fathoms, being observable near the top of the cone, where their position is most horizontal. The two beds do not wholly consist of porcelain-earth, but contain much quartz, hard felspar, mica, and pinite, all which are very irregularly distributed, the earth constituting only from a fourth to a fifth part of the solid contents of the mass. The purest unmixed earth was found in the upper bed, immediately in contact with the micaceous slate, which formed a covering of from three to four fathoms in thickness, and the fineness and friability of this earth was observed to diminish as it lay deeper, until it passed through all the degrees of induration, and terminated in a firm crystallization of felspar. Mr. O. has omitted to say whether the same gradation is observable in the lower bed of this earth; nor does he give us any other particulars of these two beds, except that the quartz and the mica occurred in such large masses as to be easily separated by the hand. With respect, however, to the intervening bed of granite, Mr. O. observes, that its composition fully corresponds with that of the main rock below, except that it contains here and there pieces of quartz, which occasionally attain a large size, and penetrate the two beds of porcelain-earth.

Next to Aue, the principal spot in Saxony where the porcelain-earth is obtained, is the village of Seilitz, near Meissen. Mr. O. was unable to ascertain the geognostical relation of this deposit to the fundamental rock. It is twenty feet in thickness, and is said to have a covering of clay which contains shells. The rock below it is a porphyry. This deposit consists throughout of porcelain-earth, mixed with grains of quartz, and particles of a greyish clay. Much variation is therefore observable in its quality, some portion of it containing masses of the pure earth of the size of a man's fist or upwards. The earth is easily separated by means of water.

This earth is more free from oxide of iron than that from Aue; but it shrinks more in the fire, and yields not so durable a porcelain. Mr. O. is of opinion that this deposit of earth has been formed by a decomposition of porphyry.

The next account of porcelain-earth refers to that which is dug in the principality of Passau, and which supplies the royal manufactories at Vienna and Munich. This report was drawn up by Mr. Gehlen, and was first printed in the Transactions of the Royal Academy of Munich, and afterwards reprinted in the second volume of Von Moll's Annals of Mining and Metallurgy.

According to Mr. Gehlen, the earth is found in a district of gneiss and granite, which rocks are, for the most part, near the surface, in a state of great decomposition, although subject in this respect to much variation; for instance, while the felspar in some situations occurs in every stage of disintegration, it is in others entire and unaltered, and in this last state it constitutes the rock which lies immediately over the fine porcelain-earth. The chief deposits of this earth are formed by stratified masses of decomposed felspar, alternating with a very decomposed gneiss, the beds of which underlie in an angle of 45° towards all the points of the compass, although to no great extent in any direction. These beds of porcelain-earth have a thin coating, above and below, of variously coloured earth, striped with a pure white substance containing small scales of half-decomposed mica. The writer observes that while the felspar on the one hand occurs in every possible stage of decomposition, the porcelain-earth on the other exhibits various degrees of fineness or of solution, some of it being so pure and impalpable as to be wholly suspended in running water, and other portions retaining a sort of grittiness to the touch, which seems to be occasioned by an imperfect or disturbed crystallization. The occurrence of the pure earth is very uncertain, which circumstance gives occasion to the greatest irregularity in the mining operations, which are here carried on in search of it; and to this, as well as to the decomposed state of a portion of the stratified rock, must be ascribed the frequent subsidences of the ground which have taken place, as well as the great expense of obtaining any quantity of the pure earth.

The particulars which Mr. Gehlen has published of the geognostical character and relations of the porcelain-earth of Passau appear to have given rise to a memoir of some length, on the origin of this earth, by another chemist, which has been printed in the Transactions of the same Academy.

The author of this memoir, Professor Fuchs, of Landshut, begins with the remark that the friable materials are in part originally formed as we find them, and in part originate in the decomposition of others. In many, he says, it is difficult to determine whether they have this or that origin, and this is the case with the porcelain-earth. Most mineralogists, indeed, believe that this question has been long settled, and they take for granted that the porcelain-earth has been formed by the decomposition of felspar; but there is so much to be said against this opinion, that we may justly wonder, he says, that it has ever been adopted by men of any eminence in science.

The principal arguments upon which he rests his opposition to this hypothesis, are the total absence of all traces of potash in the waters which flow from the decomposed mass of granite, and the occurrence of the purest porcelain-earth inclosed in felspar, and, *vice versa*, of felspar in porcelain-earth. He is nevertheless by no means disposed to adopt the opinion of this earth being an original product of nature; the prismatic form in which it is occasionally found, and the regular impressions which are often left by it in the firm rock, satisfactorily proving, as he thinks, an original form of crystallization. For these reasons, and because the researches of Klaproth had shown how many different substances had been hitherto confounded under the generic name of felspar, Mr. F. was led to the conjecture that the porcelain-earth of Passau might owe its origin to some peculiar mineral, which, like Labrador spar, and some other substances, had been mistaken for felspar. It was with a view to the decision of this question that he visited the pits where the best earth was dug, and directed his attention particularly to the felspar which was said by Gehlen to form by its decomposition the porcelain-earth. Here he found what he had suspected, that the mineral so named was essentially different, in its form and other characters, from felspar. The rock in which the

crystals of this mineral substance lie is a fine-grained or aggregated felspar, of a greyish colour. Few, however, of these crystals are entire; nearly all of them are, more or less, decomposed, having lost their lustre, their hardness, and their transparency, so that only the outward or crystallized form remains, and this friable mineral has all the properties of porcelain-earth. Acids, he says, have no effect on the hard crystals of this mineral, until they are reduced to powder, and digested in muriatic or nitrous acid, when a portion is dissolved. He then proceeds to relate the method which he employed for ascertaining the constituent parts of this mineral and their relative proportion. The result of his analysis afforded—of

| | |
|---|---|
| Silica | 49, 30 |
| Alumine | 27, 90 |
| Lime | 14, 42 |
| Soda | 5, 46 |
| Water | 0, 90 |

Mr. Fuchs thinks himself justified by this result, and the form of its crystallization, as well as its other characters, to consider this mineral as a new species, distinct from any known species of felspar, and to bestow on it the name of porcelain-spar, under which name I find it arranged in some of the most recent systems of mineralogy. He next proceeds to the analysis of the earth which he supposes to have been formed by the decomposition of the porcelain-spar. This earth, in its pure, compact, and natural state, produced—

| | |
|---|---|
| Silica | 46, 70 |
| Alumine | 31, 80 |
| Lime | 0, 46 |
| Oxide of Iron | 0, 82 |
| Felspar* | 3, 00 |
| Water | 17, 14 |

The same porcelain-earth, after a process of suspension and subsidence in water, yielded nearly the same results; nor was there

* The felspar accidentally mixed.

any material difference in that which was obtained by the analysis of the same earth in what he calls its crystallized form. Here it is proper to remark, that Mr. F. seems to regard the porcelain-earth of Aue, in Saxony, as precisely similar to this. The conclusion which he draws from this inquiry is, that the porcelain earth of Passau has originated in the decomposition of porcelain-spar, the mineral which he here discovered; for the proofs of which he refers to the gradual and obvious transition of the porcelain-spar into porcelain-earth; to the association of the two substances; and lastly, to the correspondence, which, by-the-bye, is not very apparent, between the chemical constitution of the one and the other. As for the process of decomposition, says he, it may be satisfactorily explained; for in such a complicated mixture as this is, the presence of soda and the calcareous earth must have disposed the porcelain-spar to yield to the active agency of water and the carbonic acid, by which all the soda and the lime have been carried off in a state of solution, together with a portion of the silica. But here it is that Mr. F. feels sensible of the difficulties in which he is involved by the arguments which he had already made use of in opposition to this same hypothesis, and has recourse to a sort of reasoning which bears some resemblance to our special pleading. Where, says he, these other constituent parts of the porcelain-spar have been carried after their separation—whether they have penetrated the adjoining strata, and have produced there certain changes, or, dissolved in water, have emerged to the surface, and created mineral springs—cannot be ascertained. The last supposition, however, is the most probable; and even if we should not meet with such a spring in this district, it will make no difference in the conclusion; for it must have ceased to exist as soon as the process of decomposition was over, and this because, with the exception of the few crystals which are enclosed in the felspar, no undecomposed porcelain-spar is to be found anywhere. Not satisfied, however, with the conclusiveness of these arguments, he adds: "Admitting, as it may be said, that you have proved the origin of the porcelain-earth from the mineral which you call porcelain-spar, it by no means follows that all the porcelain-earth has been so formed; some of it may be an original production of nature, and some may

have been derived from felspar or some other mineral. To this he would reply, that as the porcelain-earth, as far as his knowledge extends, is found only in the strata of primitive mountains which have been produced by solution and precipitation, and as all are more or less of a crystalline structure, it is by no means probable that the earth should have been formed originally as it is now found; for a precipitation of this sort would be a very uncommon phenomenon in primitive mountains. Nor is it less improbable that it should be derived wholly from felspar; for this, on account of its large proportions of silica, has scarcely any tendency to decomposition, and the naked rocks of granite which lie on the surface of the earth, obstinately resist all the agencies which destroy most other minerals; and granting that something of this nature may be going on here and there in the interior of the earth, it cannot be supposed to extend far, and nowhere through entire strata or lodes, but occurs only partially, and the result is not porcelain-earth, but a steatitical clay.

"It is, nevertheless, not to be denied," says he, "that in rocks which contain felspar as one of their component parts, and especially in granite, gneiss, and porphyry, a mineral very much resembling porcelain-earth is often found, which has the appearance of having been formed by the decomposition of felspar, of the structure of which it exhibits some vestiges; yet, as undecomposed felspar is usually found near it, there is much reason to doubt whether the friable earth has been formed in this way." He escapes from this dilemma by expressing a belief "that besides Labrador stone, felsite and weïss stein, some other species of felspar may be found which readily decomposes, and thereby forms either real porcelain-earth (Kaolin) or a mineral very much like it."

It is in this very unsatisfactory way that Mr. Fuchs endeavours to account for the difference which he has ascertained, between the constituent parts of the porcelain-earth of Passau, and the mineral from which he has combatted his own arguments, and not very successfully; for after all that he has said in proof of the secondary origin of the porcelain-earth, in the latter part of his memoir, he has by no means weakened those arguments which were in the former part advanced against it.

I shall now return to Mr. Gehlen, who takes a different view of the subject, and reasons more consistently.

"It remains for me," says he, "to speak of the natural history of the porcelain-earth, and the use to which it is applied. I have already quoted the opinion which is universally adopted, of its originating in the decomposition of the felspar, and noticed its occurrence in a country of primitive formation, as well as the circumstance of its being found in its original position. This opinion of the origin of the earth is corroborated in fact by all the circumstances under which it occurs, both in the district above mentioned, and at Aue, in Saxony, where the beds of porcelain-earth lie in a rock of granite, which, by the decomposition of the felspar, is in a state of perfect disintegration. The various degrees too of decomposition through which the felspar passes, in which, with the loss of all its other characters, it retains those of its original structure, seem to confirm this hypothesis. On the other hand, if we contemplate the very great difference which is found between the chemical composition of the felspar and that of the earth, we must feel inclined to the belief that they can have no common origin, and that each is aboriginal. According to the recent analyses of the best chemists, the felspar contains a very great proportion of silica, as well as a considerable quantity of potash, while the porcelain-earth is found to contain not a trace of potash, and a much smaller proportion of silica. Rose found in the Saxon felspar 52, 0 of Silica, 47, 0 of alumine, and 0, 33 of iron oxide. According to a preliminary analysis, which I made some time ago, of the washed porcelain-earth of Passau, it consists of 55 of silica, 42, 5 of alumine, 1 of lime, and 1 of oxide of iron; while in the felspar from Kellberg, near Passau, I found 63, 0 of silica, and 20, 0 of alumine, besides potash, lime, and some iron. How then can so considerable a difference as this is, in the mixture of these two substances, have arisen from a process of decomposition? If we suppose this process to have set free the potash, which was afterwards carried off by the water, yet it is but reasonable to suppose that the proportions of the other constituent parts would have remained unaltered. This difficulty," he adds, "cannot be removed by the supposition that the potash may have carried off a

portion of the silica in a state of solution, and thus have increased the relative proportion of alumine; for there are many chemical facts which oppose this conjecture, and it must be abandoned as untenable."

Mr. Gehlen concludes without advancing any fixed opinion upon this very interesting question. Nor can I find among the voluminous writings of the German geologists any serious attempt made to settle it. The hypothesis of the secondary origin of porcelain-earth seems to have been generally adopted on the Continent.

The constituent parts of our common felspar having been ascertained by the most eminent chemists of Europe, I have added the results of the several analyses which they have made of it.

| | The Green Felspar of Siberia. *Vauquelin* | Felspar of Lommitz. *Rose.* | Felspar of Bavaria. *Bucholz.* | Felspar of Carlsbad. *Klaproth.* | Porcelain-Earth of Saxony. *Rose.* |
|---|---|---|---|---|---|
| Silica | 62, 83 | 66, 75 | 60, 25 | 64, 50 | 52, 00 |
| Alumine | 17, 02 | 17, 50 | 22, 00 | 19, 75 | 47, 00 |
| Lime | 03, 00 | 01, 25 | 00, 75 | ..... | ..... |
| Aluminous Lime | ..... | ..... | 00, 50 | ..... | ..... |
| Oxide of Iron | 01, 00 | 00, 75 | ..... | 01, 75 | 00, 33 |
| Potash | 16, 00 | 12, 00 | 14, 00 | 11, 50 | ..... |
| Water | ..... | ..... | 01, 00 | 00, 75 | ..... |

# NOTICES.

## *Notice of the Serpentine of Pennare.*

**Communicated by The Rev. CANON ROGERS, in a Letter to the Secretary.**

Dear Sir,—Having been informed by my friend Mr. Trist that Mr. De la Beche and Mr. McLachlan had found serpentine near Pennare Point, in the parish of Veryan, I went with Mr. Trist to the spot, and send you, for the Cornwall Geological Society, some specimens, the result of our morning excursion, with a few short remarks on this interesting discovery.

After passing the quarry, mentioned by Dr. Boase, near Treganenna, and rightly stated by Mr. W. Tweedy to be of greenstone,* we found the serpentine cropping out on the eastern side of the headland which terminates in Pennare Point. It bears a much closer resemblance to the serpentine of Clickertor, near Liskeard, than to that of the Lizard district. It appears in small patches; and lower down the hill, and towards the beach, it is in such a state of decomposition as not to be easily recognized. The serpentine of Pennare has many of the same minerals associated with it as are found in the Lizard district. Greenstone of different degrees of induration, sienite, steatite, calcareous spar in thin layers, hornstone, or as it is sometimes, and perhaps more correctly, called, slaty felspar rock, and traces of asbestus and of fibrous calcareous spar. Some specimens bear much resemblance to jade, which has

* Transactions of the Cornwall Geological Society, vol. iv., p. 266.

been found in a rock near Caerhayes. The steatite may be observed in the cliff near the small bay, lying towards the east of Pennare Point. It is a constituent part of a decomposing rock containing imbedded fragments of serpentine. I searched in vain for the tremolite of Clickertor: and neither the asbestus nor the steatite are well defined. It is worthy of remark that the serpentine of Pennare appears in the mass to lie in a straight line with Porthalla on the south-west, the termination of the Lizard serpentine, and Duporth on the north-east, where the serpentine was probably quarried of which the porch of St. Blazey church was built. The serpentine of Clickertor lies to the south of this line. The potstone of Pollaphant would lead us to expect the presence of serpentine in that neighbourhood; and further and more accurate examination may perhaps add to those localities of serpentine in this county, which, with the exception of the Lizard district, have all been discovered within a few years. The serpentine of Pennare has, till very lately, escaped the notice of all geologists, and these brief remarks, the result of a very slight examination, may rather serve to induce persons who have both intelligence and leisure to examine the dip and relative position of this mineral, and the character of the associated rocks, than to give satisfaction to the geologist.

I am, dear Sir,

Your faithful Servant,

J. ROGERS.

*Notice of an Ancient Smelting-place of Tin, generally called a Jews' House, lately discovered on the estate of Trereife, near Penzance.*

Communicated by The Rev. C. V. Le GRICE to Joseph Carne, Esq.

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Why these ancient smelting-places were called Jews' Houses it is not easy to conjecture, unless it was because the tin mines and tin trade, at the earliest period of their authentic history, were in the hands of the Jews, and it was therefore supposed that they were the principal parties concerned in still earlier times.

The remains of several of these places have been from time to time discovered in Cornwall, generally very near ancient stream-works, or the remains of the earliest mines, of which the works were all open to the sun. All that is usually seen is a narrow shallow pit, with a small quantity of charcoal ashes at the bottom, and frequently a piece of the smelted tin, which, although very pure in itself, is generally mixed with earth or sand, often vitrified. Tradition describes the earliest mode of smelting tin as of the simplest kind possible: a small excavation was made in the earth or sand, and small sticks were piled crosswise on each other, as high as they would easily stand, and, the crevices being filled with tin ore, the pile was set on fire, and the tin being smelted, ran to the bottom, where it became mixed with the loose earth or sand.

It is remarkable that Humboldt gives a similar traditionary account of the ancient mode practised by the Indians of South America in smelting their silver ores.

It is evident that only the purest and most fusible tin-ore could have been smelted in this way. Masses of tin supposed to have been so smelted are not uncommon. They are generally called Jews' Bowls. The largest I have heard of weighed thirty-four pounds:

it was found in a hedge in the parish of Gwinear, and having been offered for sale at the Angarrack Smelting House, the Goth of a refiner put it at once into a ladle and melted it down.

There is on the table one which was found in a stream-work in St. Just, weighing about six pounds. It is largely mixed with a sandy substance, and the outside is decomposing, as is frequently the case with the Jews' Bowls. The late Rev. Mr. Gregor analysed the decomposed part, and found it was muriate of tin: it is difficult to conjecture where the muriatic acid could have come from: Mr. Henwood has conjectured that dried sea-weed might have been used for fuel in the smelting. Even now this article forms a large portion of the fuel of the Scilly Islanders.

There is another on the table, which was found, only a few months ago, in Bossuliack Croft, near Lanyon, in Madron, in the centre of a barrow. The tin is of the purest kind, but mixed with vitrified matter. It is quite free from decomposition; but there is a crystalline substance connected with it, which is a combination of tin with chloric acid. This, under the old nomenclature, would be called muriate of tin. This piece of tin had doubtless been removed from the spot where it was smelted, as, about two feet below where it was found, there were flat stones covering a small cavity containing ashes, &c., evidently a place of sepulture.

In describing this earliest mode of smelting tin, I well know that I have related little that is not already known to most of those who have heard it, and it has been introduced only to show its connexion with the mode which appears to have been adopted at a later period; to which the spot which forms the principal subject of this communication seems to belong.

The smelting-place discovered at Trereife is (or I should rather say was) of quite a different character from those which have been already alluded to. As the workmen, during the absence of the proprietor of the estate, had removed the whole from the spot where they discovered it, the form, dimensions, and other particulars could only be known by very particular enquiry.

It was situated in the middle of a high bank of compact clay, which the workmen were removing, and when they dug into it, they found a space whose form was that of an inverted cone, about

three feet wide at the top, and three feet high. At the bottom was a flat stone, scarcely a foot in diameter, which had a border of small stones around its edge. On the flat stone were some unctuous ashes, doubtless of charcoal. The sides of this inverted cone, or furnace, for such it undoubtedly was, consisted only of hard clay. On one side of the bank of clay was a small ravine, by which it is probable a blast of air was conveyed, perhaps by a common bellows, to the lower part of the furnace, and by which also the smelted tin was discharged. The furnace, when discovered, was filled with earth and rubble, on the top of which was found the slab of tin now on the table, of the weight of twenty-six pounds.* It could not have been smelted where it was found, but was probably placed there with the intention of subsequently removing it, but which was never done. From an examination of the slab, it will appear evidently to have been cast in a mould, as the Roman letters E I C, with a figure of a cross surmounted by a kind of standard which very much resembles the Roman Labarum, are in relief on one side.

The situation of this smelting-place must have been very appropriate. On one side of it, within a few hundred yards, are the remains of the ancient tin-work of Trewidden, where the large excavations, still open, make it probable that an immense quantity of tin-ore was found there, not far below the surface. In another direction, not far from it, is Huel Garth, now called Huel Darby, where also, some time ago, were the remains of ancient mining, and which has recently been remarkable for the production of wood-tin in the upper part of the vein; but independently of these, there are remains of an extensive stream-work quite close to the smelting-place, which, however, will not long be visible, as the common is being improved.

With respect to the period when this mode of smelting tin was first resorted to, it may, perhaps, be not an improbable conjecture that the first or earliest method which has been alluded to was that of the Britons, and was continued by them until they were

* This has been presented, by the Rev. C. V. Le Grice, to the Natural History and Antiquarian Society of Penzance.

conquered by a people more highly civilized than themselves. The smelting-place at Trereife was, probably, an improvement introduced by the Romans, and seems to be a specimen of the very earliest kind of blast furnaces, or blowing-houses, the name long afterwards given to them. These furnaces were gradually enlarged and improved until they arrived at the form now in use, which, in fact, is little more than an inverted cone swelled out in the middle. Small blast furnaces were so easily erected that they were formerly very common in Cornwall, and have given the name to several localities, of which there is an instance in "Blowing-House Hill," near Redruth.

Tin was continued to be smelted in blast furnaces only, until within the last two hundred years, for reverberatory furnaces, such as are now used, are of comparatively recent date: the reason of this appears to have been the general persuasion, that to melt tin with pit-coal would greatly injure its quality. The first furnace of this kind was erected at Calenick, near Truro; the second at Angarrack, near Hayle.

The fact that this slab of tin was smelted in the time of the Romans, is rendered more probable in that it was a common custom with that people to affix letters, and even inscriptions, on the melted slabs of different metals. Pennant, in his "Wales," mentions several pigs of lead found in the Roman smelting-places, some with letters, and others with contracted words, all in raised capitals. He also mentions the discovery of a cake of copper, in shape like a cake of beeswax, with letters on it.

# *Additional contributions to the Mineralogy of the Parish of St. Just.*

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The parish of St. Just is undoubtedly one of the most interesting districts, with respect both to its geology and mineralogy, and one of the most fertile and productive, with regard to the number and variety of its minerals, that exists in this or perhaps in any other country. Indeed so different is it from every other part of Cornwall, that occurrences which would be deemed singular and extraordinary elsewhere excite little astonishment here. The associations and combinations of its different minerals are such as are met with nowhere else.

A few years ago, a descriptive account of the minerals known to have been found in St. Just, astonishingly numerous and various, was laid before the society, and subsequently published in its Transactions.* Since that period many additional minerals, and additional varieties, have been found, which were not previously known to exist there. A short description of these will not be altogether useless, if it only conveys additional information to the mineralogists who may hereafter visit that district.

The minerals discovered since the publication before mentioned may be divided into two classes. The first class are either massive, or crystallized in their natural or regular forms; or they are in new associations. Here may be mentioned arragonite of a white and brownish-white colour, botryoidal, and in hexahedral prisms; and also of a deep red colour, both in concretions, and crystallized in hexahedral prisms, some of which are crowned with very obtuse